The Graduate Committee for Meredith Jeanette Brown
Certifies that this is the approved version of the following Thesis:

Declining Household Plumbing in Certain Alaskan Census-Designated and Incorporated Places

APPROVED BY
SUPERVISING COMMITTEE:

Kasey Faust, Supervisor

Randy Machemehl

Declining Household Plumbing in Certain Alaskan Census-Designated and Incorporated Places

by

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Abstract

Declining Household Water Access in Certain Alaskan Census-Designated and Incorporated Places

Meredith Jeanette Brown, M.S.E.
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Supervisor: Dr. Kasey Faust (Supervisor)

Water service via in-home plumbing has long been established in the majority of homes in the US; however, notably, some communities throughout the US do not have widespread, complete, and operational plumbing in all households. Many census-defined and incorporated places in Alaska have decreasing access to water service at the household level, even though previously US regions lacking access to household plumbing are assumed to only improve over time. This research seeks to identify: (1) which Alaskan places are facing a decline in water access over time, through thematic mapping, and (2) parameters that influence this worsening access of water services as measured through the number of households in a community that lack complete plumbing. Enabled by the American Community Survey 2011-2015 data, the temporal change in complete plumbing facilities inside of Alaskan homes is calculated for each place. Thematic mapping illustrates that several places in Alaska are facing a decrease in water access between 2011 and 2015. Sociodemographic predictors influencing the percentage of homes that lack complete plumbing are revealed through a fixed effects regression model. We find that decline in water access at the household level is influenced by the percentage of households in a community with an income

under $30,000 per year; percentage of households who receive some type of welfare including Social Security Income, Public Assistance Income, SNAP and retirement income; the proportion of males in the place's population; and percentage of households without complete kitchen facilities. This information can help water planning boards and municipal bodies better understand the root causes of plumbing decline to make effective and efficient policy to combat and prevent decline.

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CHAPTER 1: INTRODUCTION

In-home plumbing is an everyday reality for a majority of residents of the United States as determined through the decennial census and the American Community Survey [1]. In fact, such a large proportion of American homes are plumbed that international statistics and information on water access do not focus on the United States, or any other developed nation. However, this is not the case in some American homes. This omission often leaves American homes that lack complete plumbing understudied [2]. According to the Anchorage Daily News in 2016, approximately 12,000 Alaskans lived without in-home plumbing [3]. This dichotomy between the assumption of complete plumbing in the United States and the reality of lower-income Alaskan homes lacking this infrastructure leads to dangerous racial and income disparities as compared to more wealthy communities on the mainland United States [1].

While regular access to water is absolutely critical to high quality of life, estimates show that about 22% of occupied homes in the state of Alaska do not have in-home plumbing to receive water. In fact, some Alaskan citizens and residents of desert Mali consume comparable amounts of water - about 1.7 GCPD [4], when the national average is approximately 83 GPCD [5]. This shocking similarity captured the interest of researchers who investigate lack of water's impact on cultural norms like gender roles and water-hauling practices [5 - 6] Access to safe drinking water at adequate quantities in the home is so intrinsically coupled to health and overall well-being. Researchers have shown that areas in Alaska with low rates of in-home plumbing have high severe and distinct negative health trends as compared to plumbed counterparts [7 - 8].

Existing studies assessing homes lacking access are cross-sectional and focus on plumbing at a singular moment in time, leaving a gap in knowledge regarding if complete plumbing facilities—or improved water access—are increasing or decreasing. It is often assumed that rates of plumbed homes only increase in the US [1]. Several communities are known to have low rates of plumbing, and this assumption leaves these groups unstudied in a temporal context. These communities include informal settlements at the United States-Mexico border, tribal communities around the United States, and Appalachia [9-10], among others. This knowledge is critical because plumbing decline indicates that a water system is actively failing or nonexistent, potentially cascading to public health and quality of life. The root causes this decrease must be targeted and alleviated by policymakers. For instance, data that shows that low-income elderly populations are more likely to experience plumbing decrease could prompt policymakers in Alaska to provide a home repair welfare fund for this population, specifically. Target policy like this example may be more efficient at stopping this decline in plumbing access.

Utilizing data from the American Community Survey (ACS) [11-25], this study maps hot spots, or regions of relative strong in-home plumbing decline, between 2011 and 2015 in Alaskan census-defined and incorporated places and will characterize the certain socio-demographic truths that are statistically tied to this decline. An incorporated place is defined as a town or village with a legal border, and a census-designated place is simply a population concentrated in a region by the census for statistical reasons [26]. For this study, both census-designated and incorporated places are referred to as *places*; this is the lowest resolution of data statewide available. For instance, only 167 census tracts exist in Alaska, while 355 place delineations exist. Figure 1 shows the census-defined and incorporated places in Alaska investigated here.

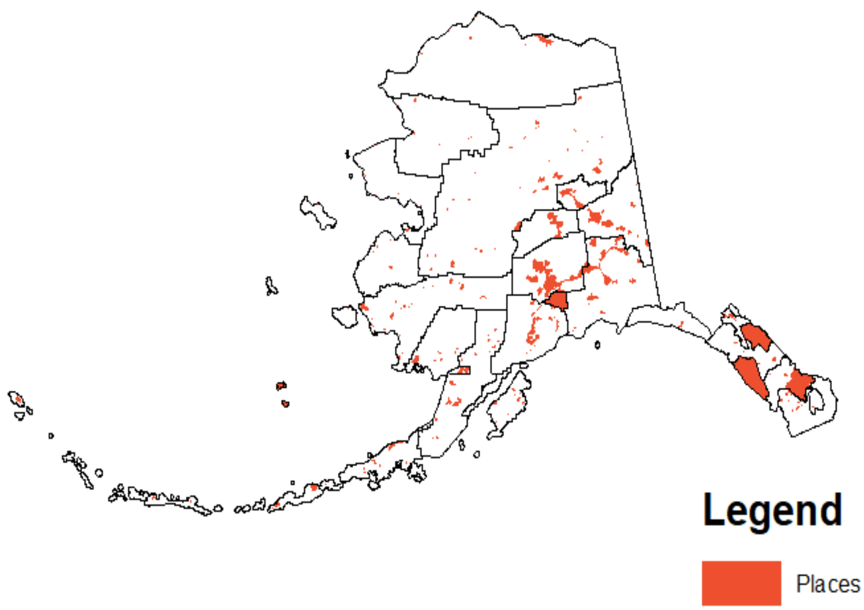

Figure 1: Census-Designated & Incorporated Places in Alaska

Previous work found identified racial and income minority status impacts plumbing rates [1]; however we posit that other socio-demographic elements also affect rates of complete plumbing facilities, and thereby water access in a household. By identifying parameters that impact water insecurity in Alaskan homes, policymakers will be able to more efficiently solve this problem. For example, by characterizing a place that has rates of incomplete plumbing facilities through parameters such as income of the existing population, policymakers can focus on local economic investment and rebuilding of infrastructure.

CHAPTER 2: LITERATURE REVIEW

Although several studies exist on the presence of water insecurity in Alaska, no study has been looked at the decline of water access over time and where such decline is occurring. The literature discussed is divided by developing countries and the United States (including Alaska). Within each category we consider two sub-categories: factors that lead to a lack of plumbing and the implications of a lack of plumbing. Factors are defined here as root causes of reduced plumbing rates in a community. For example, a factor might be aging infrastructure or historical disinvestment. Implications are defined as the cascading impacts of absent plumbing, such as disruptions to daily life and public health. For instance, an example of a disruption to daily life could be defecating in a bucket, rather than a flushable toilet [2, 27]. By understanding the factors (cause) and implications (effect) of absent plumbing, we begin to understand possible socio-demographic variables that are correlated with incomplete plumbing facilities.

Separating the literature by developing countries and the United States is not for simplicity. Rather, this separation sets up the image of Alaska. The state of Alaska exists in the crossover between these two distinct types of operating context, despite being classified as a state within the United States. Alaska fits cleanly into neither category, and by straddling both developed and developing identities, unique crises are formed. On one hand, one could argue that Alaska is within the United States, providing it access to strong governance structures and economic networks. However, Alaska also is home to a notably disenfranchised indigenous population. Far distances to polling places combined with lack of transportation access, language barriers, and lack of internet access for voting registration and information are all noted factors that cause Native Americans to have the lowest voting rate of any other ethnicity [28]. Physical features also make Alaska unique from the mainland United States. Alaska has permafrost – permanently frozen ground that requires special construction tactics and it also makes subterraneous upkeep of infrastructure costly and difficult [29 - 30]. In addition, as Alaska is not densely populated, construction crews must travel long distances to serve a small community of people [30].

One could argue that much of Alaska's water infrastructure is operating in a context more similar to that of developing countries rather than the United States. However, literature regarding the United States is included to highlight that communities without in-home plumbing are very isolated and not widespread, insinuating that lack of in-home plumbing is caused by localized problems rather than widespread lack of infrastructure as in developing countries. Factors and implications are deemed the two important sub-categories because implications show the importance of this problem, and factors indicate the first steps to fixing it.

Notably, water access has been extensively studied in the context of water quality, which is an important piece of greater water insecurity but will not be covered in this study. The state of Alaska has identified several nonpoint sources as the cause of surface water and groundwater pollution that extend beyond water infrastructure failure [31]. Here, we focus on the physical lack of in-home infrastructure or the inability of existing infrastructure to carry water, rather than the quality of water itself. Figure 2 below outlines the body of this literature review. These studies were selected by focusing the search to water access and water insecurity in Alaska. Themes from the literature specifically on Alaska were used to find applicable studies from developing countries, in order to highlight the unique position of Alaska where it embodies the identity of the United States and developing countries.

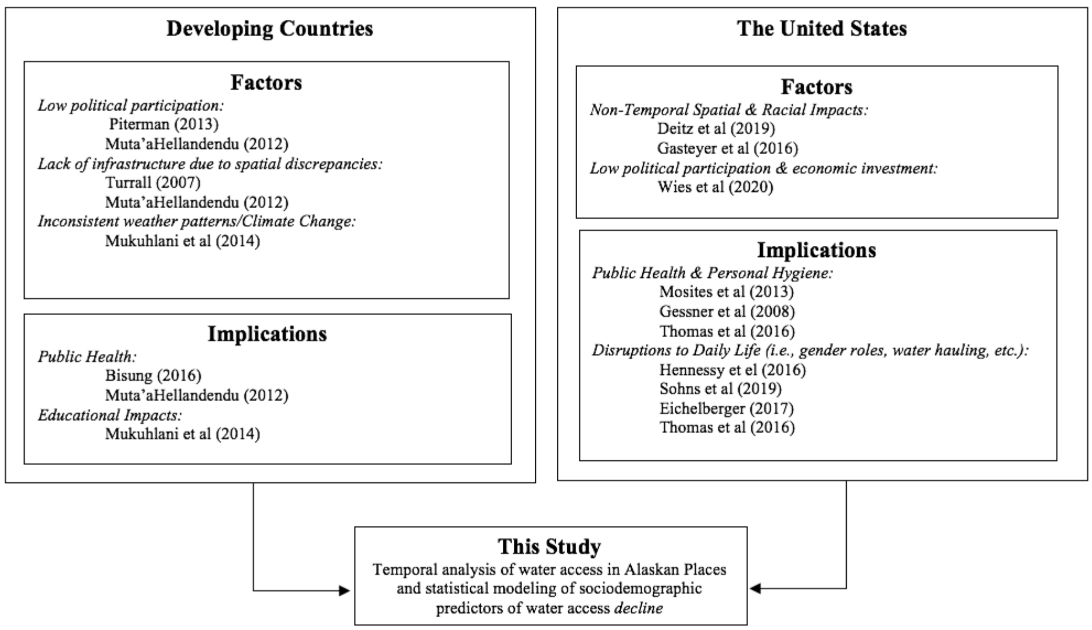

Figure 2: Literature Review Description

2.1 Factors Leading to Decreased Water Access in Developing Communities

Literature regarding the factors leading to decreased water access in developing communities and the corresponding impacts on health and daily routines tend to focus on low- and middle-income countries rather than on high-income countries, leaving the United States largely understudied [2]. For instance, in several African countries, many infrastructure systems are subpar or completely lacking, depending on geographic location (e.g., rural vs urban), including a clean and reliable water source, water treatment and delivery facilities, and in-home plumbing, rather than failures of existing infrastructure [32-34]. In fact, most African rural areas require total service extension, not upgrades, from urban areas, indicating that the water infrastructure is nonexistent in most rural areas of African countries [35]. Beyond infrastructure challenges, African countries, particularly in sub-Sahara, are susceptible to water insecurity caused by weather patterns as these communities mainly rely on surface water that is not regularly replenished, a symptom of climate change [32]. While a water source is not physical water infrastructure, without a reliable location for sourcing water, physical infrastructure cannot be constructed. Building on the issue of climate change, subterraneous water infrastructure in Alaska is at risk due to melting permafrost [29]. Climate change manifests differently between Alaska and developing countries, but the stress on water infrastructure is similar.

This stress on water infrastructure brings to light another cause of a lack of access—low rates of political participation. Because water infrastructure is funded by municipal governmental bodies, economic investment is largely determined by the preferences of the constituents. In other words, the strongest voices in government tend to have strong water infrastructure. In South America, for example, lack of water access in one small Brazilian community was attributed to poor quality plumbing consequential to a lack of participation with policymakers [36]. Pew Research Center has defined low political participation as a trademark of emerging and developing communities [37], with clear cascading consequences on access to basic utilities [36]. In the US, indigenous populations participate in government at the lowest rate of any minority [38]. Alaska is ~20% Native Alaskan [39], with much higher proportions outside of urban cities. As such, lack of engagement with political participation may at last be partially driving this lack of access seen in Alaska. This similarity between Alaska and these developing countries allows other variables that are causes of water insecurity in those countries to be tested as variables in this Alaska study.

Pollution is a significant factor in water insecurity in developing countries. Environmental activism, clean technology, and advanced treatment facilities are earmarks of the developed nations like the United States, all relatively efficient in combating polluted water. On the contrary, unclean drinking water is a major issue in developing countries as the economic resources are not available [32-33]. Water insecurity due to pollution, while a critical piece of water access as a whole, is out of scope of this project as it does not directly relate to household infrastructure.

An important difference between the water discussion in developing nations and the United States must be noted. "Water access" in developing countries is defined as access within 1,000 meters of the home, not in-home complete plumbing [40]. On the other hand, "water access" in the United States defines access as "complete plumbing facilities" to account for the established infrastructure expected in these developed contexts. This critical difference demands that literature specifically regarding water access in the United States to underscore the possible drivers causing a lack of access where there is the expectation of almost total access.

2.2 Factors of Absent Plumbing in the United States

Here, the terminology becomes “plumbing” rather than “water access” as living in the United States requires a more stringent requirement of determining who has such water access. Literature on households with complete plumbing in the United States departs from that of developing countries, as plumbing access research seeks (1) to establish that specific communities have a homes without complete plumbing and (2) that these communities differ from the vast majority of other US communities [1, 6, 9-10].

Spatial differences impact the likelihood of a community to lack access to in-home plumbing; notably, this is true for both developing nations and the United States. The key spatial indicator of water access in Nigeria, for example, is rural versus urban. For the United States, a detailed analysis is required via geospatial mapping to identify hot spots. Locations of high incomplete plumbing will present themselves as precisely that – hot spots. This method was practiced by both Deitz et al [1] and Gasteyer et al [41], two studies that concluded similarly that plumbing rates in the United States are both spatially- and socially-tied. To determine the sociodemographic predictors of this lack of complete household plumbing, both studies use linear regression of the ACS responses. Gasteyer et al [41] connect ruralness and proportion of minorities with the percentage of incomplete plumbing facilities in the United States, while Deitz et al [1] focused on showing racial disparities. These studies do an excellent job of showing that a plumbed home is not the reality for every single American [1]. However, they provide only a cross-sectional view.

Linear regression and mapping are not the only methods that can be used to correlate socio-demographic variables with plumbing. In fact, a study on Texas’ colonias, or informal settlements on the United States-Mexico border, exposes disparities in water availability that depend on age, time spent in home, gender, income, high school education, and household size [9] using data from focus groups. While the methods portion of this study does not provide the breadth for this particular study, the variables begin to shape possible predictors of water access decline in Alaska. A similar study utilizes interviews to investigate lack of water access in the Appalachia region of the United States. In this region, city water does not exist, and local investment is minimal, fingerprints of disenfranchised, isolated, and impoverished communities in the United States [10]. This study adds to the possible strength of the income and education variables on water access.

These studies are helpful in basing assumptions of socio-demographic variables for the model. However, Deitz et al [1], Garcia et al [9], Wies et al [10], and Gasteyer et al [41] are all cross-sectional and *time-invariant*. They do not identify locations or causes of increases in the proportions of households that are experiences incomplete plumbing in a community. These studies do not necessarily dispel the assumption that water infrastructure in the United States will only improve with time.

2.3 Implications of Absent Plumbing

The implications of households lacking complete plumbing—and thereby access—are not separated here by developing nations and the United States, as these implications are not characteristic to one or the other. Human health is intrinsically tied to safe regular access to clean water for cooking and bathing. Without regular access to water in the home, "daily life" is disrupted. For example, a household may make multi-day trips to haul water back to the home [2] or dispose of honey-buckets, or a self-hauling system of human waste [27].

However, this discussion cannot begin and end by labeling lack of plumbing as a mere inconvenience. Water availability is closely tied to public health. For example, extreme water conservation has been tied to the increased consumption of sugar-sweetened beverages in young adults in rural Alaska, leading to lifelong health issues such as obesity and health problems [8], and pediatric rates of lower respiratory infections are higher in homes without piped water as compared to their counterparts in homes with plumbing [7]. Similarly, one study notes that diarrheal diseases are common in these homes, as coming into close contact with raw sewage poses this danger, and handwashing is not as readily available due to the lack of plumbing [27]. Difficulty in maintaining cleanliness and safely removing human waste has cascading effects; cascading effects that develop possible variables that are statistically tied to water access decline.

These studies are critical in identifying the variables that may be tied to significant water access decline. People in poor health and with sick children may rely on welfare programs more than their healthy or childless counterparts, as studies have shown that health and income have a positive relationship [42]. The increased rates of pediatric lower respiratory disease may impact school attendance and performance, and so school enrollment could be a strong predictor of decline of plumbing, as well. The severe impact on public health showcases a gap in other issues tied to and exacerbated by lack of plumbing.

Many studies investigate the culture built around this everyday struggle of water access in communities [2, 4, 6, 10]. These studies are often done independently of the engineering context, involving the anthropological and socio-economic analysis of this critical infrastructure failure [2, 6]. For example, in both Alaskan communities and Appalachia, gender roles have been designed around collecting and hauling water [2, 10]. Able-bodied men and boys will haul water back from the town schools where clean water is brought from the water treatment facilities. This anthropological finding may indicate that gender may be a strong predictor of plumbing decline. However, both female and male gender roles are shaped by the absence of household plumbing. Bisung et al [43] links lack of access with increased psychological distress in Usoma, Kenya, particularly among women as they are the primary caretakers of children and water haulers for the family. While these studies indicate cultural differences between who is the main water-hauler for the family, the same variable is brought to interest for this particular Alaska study: gender.

2.4 Departure Point

The research completed in developing countries focuses on some root causes of water access, while the research completed on water access in the United States typically focuses on establishing that some American homes do in fact lack plumbing, which is not random. Both sectors of literature include cascading effects of water on public health and daily life. This literature provides some basis for assuming which variables in the American Community Survey may influence a lack of complete household plumbing. Further and of note, current literature does not indicate how water access changes over-time and the sociodemographic variables associated with this decline (or improvement). This study will begin to close that gap in knowledge.

CHAPTER 3: DATA AND METHODS

This study analyzes data from the American Community Survey to locate the census-defined and incorporated places—referred to here simply as places— in Alaska where the rate of households without complete plumbing is increasing. Further, this study identifies parameters that are statistically influencing the worsening water access using a fixed effects linear regression.

3.1 Data

This study is enabled by data from the ACS [11-25]. From 2007 until 2015, the United States Census Bureau conducted the American Community Survey to replace several questions on the traditional decennial census. The American Community Survey (ACS) asks detailed questions to households about sociodemographic data to gain a more holistic picture of these communities. Some examples of these variables include race, income, gender, and education. This study uses the ACS "complete plumbing facilities" question as a proxy to determining whether or not a household has water access. Complete plumbing facilities here are defined as having a flush toilet, hot and cold running water, and a bathtub or a shower [26]. Potable water being brought into the home with facilities for bathing and cooking is a standard of the United States, and alternate methods to bring water into the home that require expensive non-water infrastructure, such as a four-wheeler to haul large amounts of water should not, here, considered complete access.

The demographic data collected alongside the data of households with complete plumbing used in this study includes race, gender, and household income. Other data incorporated in the modeling process to test for statistical significance include the school enrollment of the youth population, education attainment of the population over 25 years old, the language spoken at home, receipt of social security, supplemental income, public assistance income, SNAP and retirement income, and poverty status of individuals. Important structural characteristics are year structures were built, complete kitchen facilities, and telephone service available. The year that structures were built indicates if aging infrastructure is a potential cause of a more households have incomplete plumbing. Telephone service may be important because this can be related to general connectivity to family and current events, available infrastructure, and the relative ruralness. Complete kitchen facilities were hypothesized to be important as one of the requirements of a complete kitchen is a functioning sink, tying this variable to complete plumbing facilities. Much of this sociodemographic data (income, race, gender, welfare status, poverty status, educational attainment, and school enrollment) were determined to be potentially influential from previous literature.

Each independent variable is calculated as a simple percentage of its respective population or number of total households. The tables below show how the school enrollment variable and the household income variable were estimated for two places in 2011; other variables (poverty status of individuals, race and gender of total population, build year of total housing units, and educational attainment of total population over 25 years old) were calculated similarly. The percentages highlighted in red were used in the modeling process.

Title of Place	Year	Total Population 3 years and Older	Enrolled in school (3+)	% of Total Population Over 3 Enrolled in School
Adak	2011	121	40	33.06%
Akhiok	2011	106	31	29.25%

Table 1: Independent Variable Example - School Enrollment of Population Over 3 Years Old

Title of Place (2011)	All Occupied Housing Units 2007-2011 (Households)	Less than $10,000 (Total Households)	$10,000 to $14,999 (Total Households)	$15,000 to $19,999 (Total Households)	$20,000 to $24,999 (Total Households)	$25,000 to $29,999 (Total Households)	%
Adak	54	0	5	0	0	0	9.26%
Akhiok	38	4	10	10	4	3	81.58%

Table 2: Independent Variable Example - Household Income

Literature has shown that communities without plumbing are often of low-income [1, 6, 9, 10, 41]. Racial disparities were also noted to be a key descriptor of these communities [1, 41], and as such, this was included in the model. Previous work found that isolated and rural communities are often risk for lack of water access [1, 4, 10, 41]. Educational attainment and school enrollment have been found to be important when assessing community income and access to infrastructure [10]. Welfare and poverty status are other variables that capture income and lack of resources. Finally, the year the structure was built was thought to possibly play a role in plumbing infrastructure deterioration.

3.2 Thematic Mapping

The ACS data is reported as a five-year moving average from 2007-2011, 2008-2012, 2009-2013, 2010-2014, and 2011-2015. The delta (Δ) from the end points of each moving average was calculated, as well as the delta from the farthest end points. For instance, the single average of the number of households without complete plumbing is reported in the raw data as a singular number, for a single place. After dividing by the number of occupied homes in that respective place, the resulting percentage is categorized as the 2011 percentage of homes without plumbing. This process is repeated for 2008-2012, 2009-2013, 2010-2014, and 2011-2015, resulting in five percentages for 2011, 2012, 2013, 2014, and 2015. In order to make this data show decline or improvement, the delta was calculated between each year, resulting in five distinct deltas: $\Delta_{2012\text{-}2011}$, $\Delta_{2013\text{-}2012}$, $\Delta_{2014\text{-}2013}$, $\Delta_{2015\text{-}2014}$, and $\Delta_{2015\text{-}2011}$. $\Delta_{2015\text{-}2011}$ is included to show an overview of plumbing decline.

These five deltas were mapped to the Alaskan places shapefile. Worsening water access was separated into severe decline, moderate decline, and slight decline. Small changes in percentages, from 0% to 5% are treated as unknown or neutral, as small variations in survey data is possible. Improvement in rates of households with complete plumbing is aggregated into one category, as this is not the focus of this study.

3.3 Fixed Effects Regression Model

Statistical modeling, specifically a Fixed Effect Regression Model, is used to identify parameters that influence an increase or decrease to water access in Alaskan places. The fixed effects model employs panel data, i.e., data gathered over time from the same respondents. In this case, the census-designated and incorporated places, are the respondents and represents the fixed effects. The fixed effects regression for each place (unit) can be expressed as

$$y_{it} = a_i + \boldsymbol{\beta}\mathbf{x}_{it} + \varepsilon_{it}, \qquad \text{Eq.1}$$

where y_{it} represents the dependent variable, or rate of households without incomplete plumbing facilities. $\mathbf{x}_{it}$ is the vector of the covariates and $\boldsymbol{\beta}$ is the vector of parameters that will be estimated in the model [44]. In this case, the independent variables are the following:

- Percentage of Household Making Less Than $30,000 per year
- Percentage of the total population who is white
- Percentage of the total population who is Native Alaskan
- Percentage of the total households receiving welfare (defined as receiving Social Security income, Supplemental Security Income, Public Assistance Income, Food Stamps or SNAP, or retirement income)
- Percentage of the population over 3 years old enrolled in school
- Percentage of the population over 25 years old with at least a bachelor’s degree
- Percentage of households that only speak English
- Percentage of households with telephone service available
- Percentage of Households without complete kitchen facilities

Each coefficient of x_i (dependent variable) shows how much y_i (percentage of households with complete plumbing) changes over-time, on average per place, when x_i

increases by one unit. In the above equation, the *i* represents the place. For this model, *i* = 1, …. 355, the number of places. In the above equation, *t* represents time. For this model, *t* =1, … 5, or 2011 to 2015.

Error is captured via the two variables: a_i and ε_{it}. ai is the unobserved time-constant error, or the intercept of each place. These are also called the fixed effects (Appendix 1) [44]. ε_{it} is the error across all places and years. The existence of these errors relies on repeated observations over time, making panel data the critical format to utilize this model.

The fixed effects regression model relies on the "within" transformation. This transformation is created by averaging Equation 1 to form

$$\bar{y}_i = (\boldsymbol{x}_{it} - \bar{\boldsymbol{x}}_i)\boldsymbol{\beta} + \varepsilon_{it} - \bar{\varepsilon}_i \qquad \text{Eq. 3}$$

This equation shows variations within places over time, but not across the entire unit of 355 places. The data is then calculated with the demeaned regression, as α_i is subtracted to remove time-constant bias. The estimated regression is below, Equation 4.

$$y_{it} - \bar{y}_i = \bar{\boldsymbol{x}}_i\boldsymbol{\beta} + \alpha_i + \bar{\varepsilon}_i \qquad \text{Eq. 4}$$

To see the significance of the categorical variable, the census-designated and incorporated places, ANOVA is used. These results are summarized in Table 4.

The fixed effects approach refers to how the error is estimated in this panel model. The fixed effects approach is efficient at eliminating error based on an **unobserved** effect, which is higher in studies of social situations. A fixed effects regression model assumes that there is no all-group unobserved heterogeneity, only no unit-specific unobserved heterogeneity. This assumption allows the small relationships between variables to be identified [44].

The major disadvantage to the fixed effect assumption is the removal of time-constant effects. This does not account for time-varying measurement error or feedback loops. The alternative method of estimating error is called a Random Effects model. In a Random Effects model, it is assumed that unobserved heterogeneity does not bias the estimates.

The "Hausman Test for the Exogeneity of the Unobserved Error Component" is effective in determining if a fixed effects or random effects model is a best fit for the data [45]. In order to complete this test, two competing hypotheses are defined: the alterative hypothesis, H_a, and the null hypothesis, H_0. In this test, the null hypothesis favors the random model, and the alternative hypothesis is that the Fixed Model is the consistent and preferred model.

$$H_0 : \boldsymbol{\beta}_{RE} = \boldsymbol{\beta}_{FE} \tag{Eq. 5}$$

Let $\boldsymbol{\beta}_{RE}$ and $\boldsymbol{\beta}_{FE}$ be coefficient vectors for the time-varying explanatory variables, referring to the list of independent variables listed above, not including the time variables. These are also known as estimators. If the Hausman test is significant, the random effects model is rejected in favor of the fixed effects model. This would determine that the random effects model is inconsistent. A p-value is a test of strength against the null hypothesis; thus, a p-value of less than 0.05 indicates that the fixed effects regression model is appropriate for the data [45]. When a Hausman Test was run between the fixed effects or random effects regression model, a p-value of 2.2×10^{-16} was calculated, indicating that a fixed effects regression model is more consistent with the data than a random effects model.

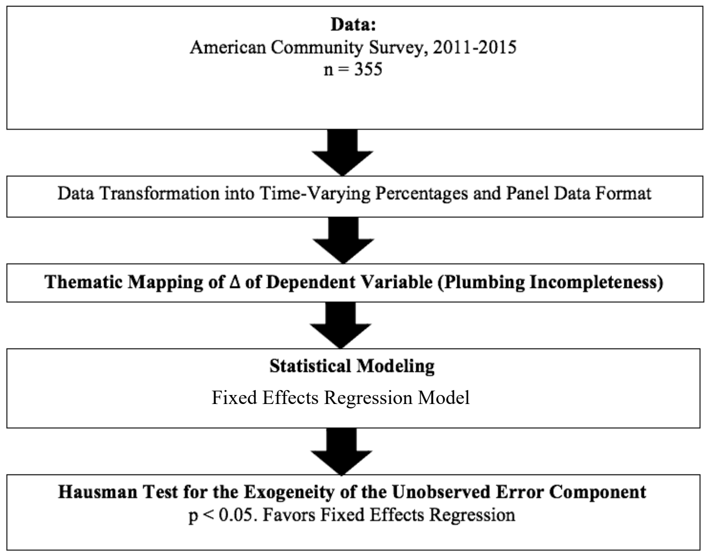

Figure 3: Outline of Methodology

CHAPTER 4: RESULTS & DISCUSSION

4.1 Thematic Maps

Figures 3 –7 are thematic maps illustrating the changes in households that lack complete plumping in each Alaskan place. The places with the largest relative decline between years is highlighted in red, and the places with improved rate of households with full plumbing are shown in dark blue. These maps expose a few critical pieces of the plumbing decline occurring in households. When viewing the maps, in general, places with the greatest decline are small and isolated. This aligns with findings in literature that rural and isolated locations tend to have the most aged infrastructure and least utility service connectivity as compared to larger and more urban counterparts [1, 6, 41].

These maps also highlight how quickly places can fall into declining access. For instance, Wrangell, in the southeast corner of the state, is maintaining the same levels of plumbing access from 2012-2013. However, in the following years, 2013-2014 and 2014-2015, this same place decreases in percentage of households with complete plumbing. The census-designed place of Livengood is a similar example. From 2011 to 2012, this place was categorized as having strong rates of complete plumbing, as indicated by dark blue. Every following year until 2015, however, this place is experiencing moderate decline. This phenomenon, however, aligns with the nature of the socio-demographic predictors of decline, discussed in the next section. Practical recommendations for state officials attempting to identify the locations of the strongest plumbing infrastructure decline would be to investigate the state of plumbing in very rural and isolated regions, as these maps indicate that they are most vulnerable to plumbing decline.

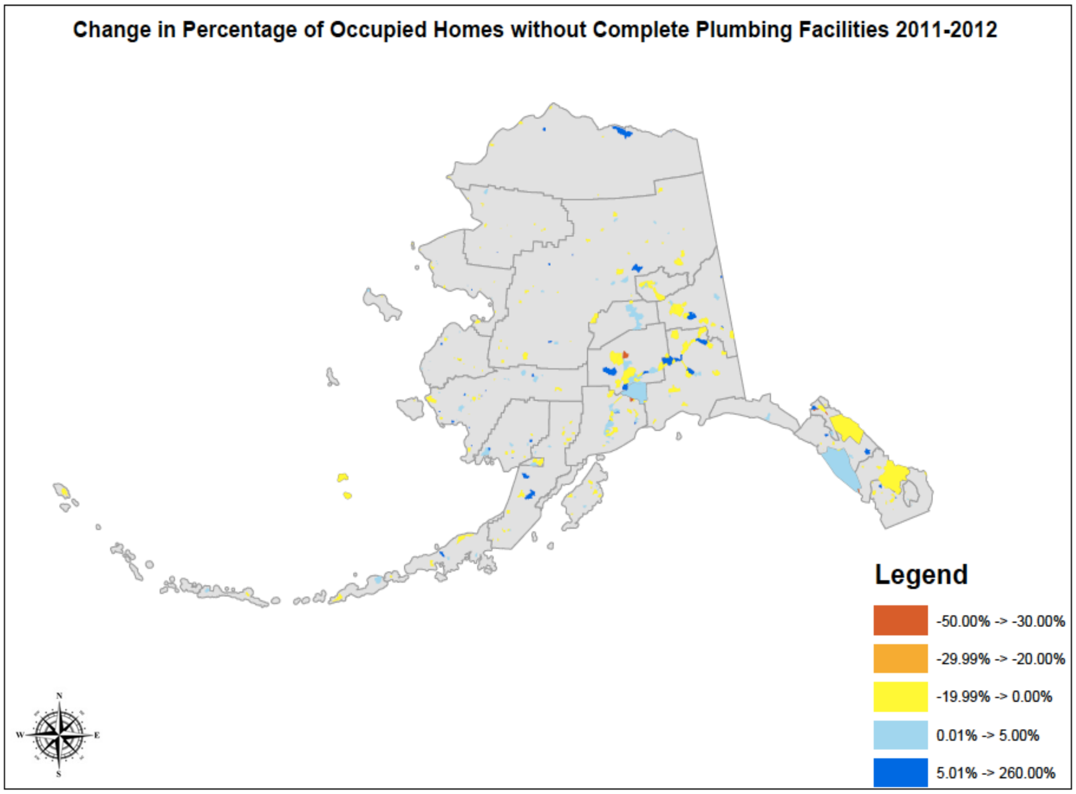

Figure 4: Change in Percentage of Occupied Homes without Complete Plumbing 2011-2012

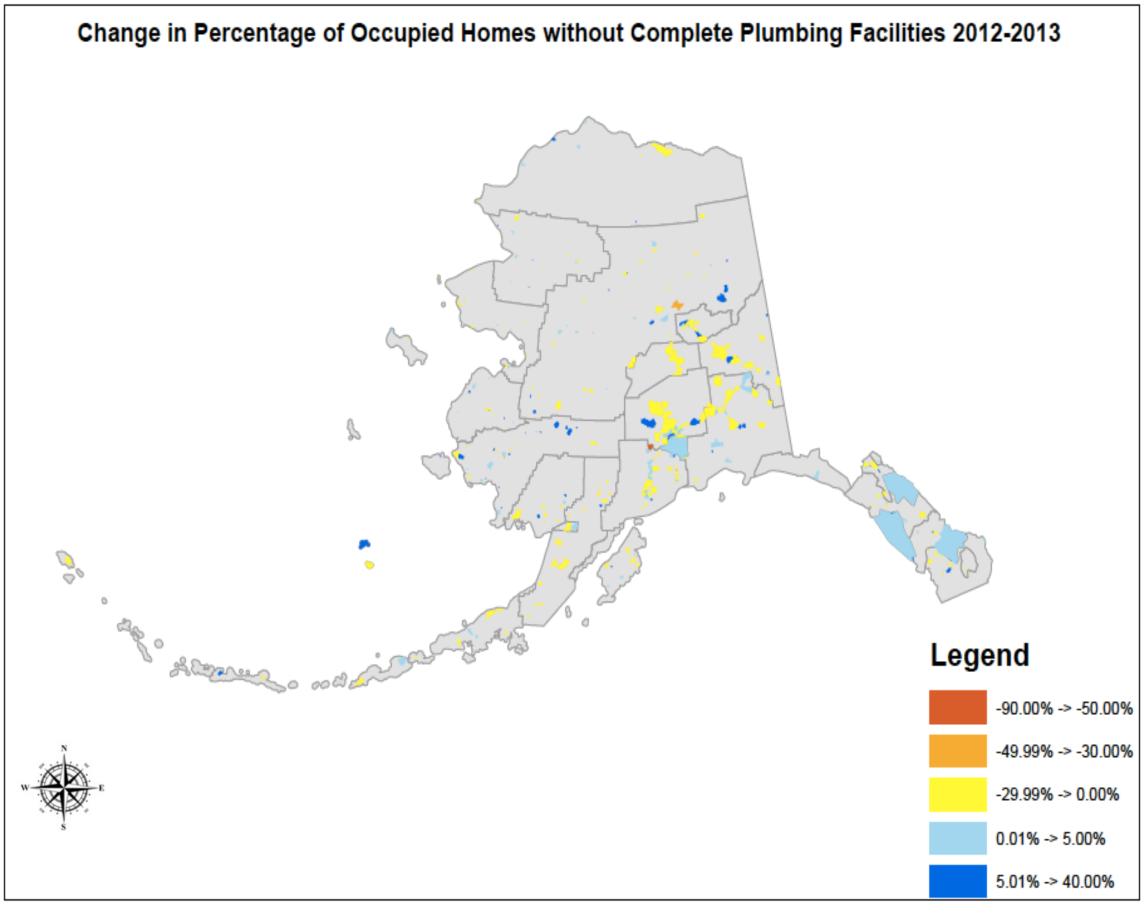

Figure 5: Change in Percentage of Occupied Homes without Complete Plumbing

2012-2013

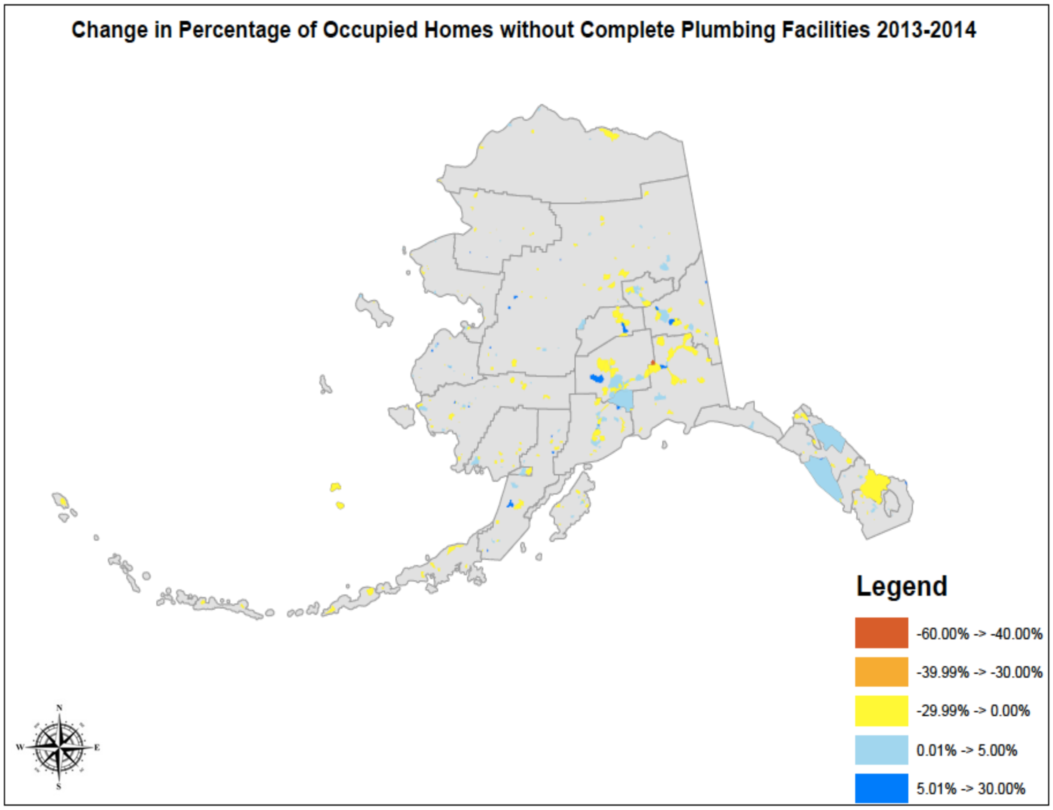

Figure 6: Change in Percentage of Occupied Homes without Complete Plumbing 2013-2014

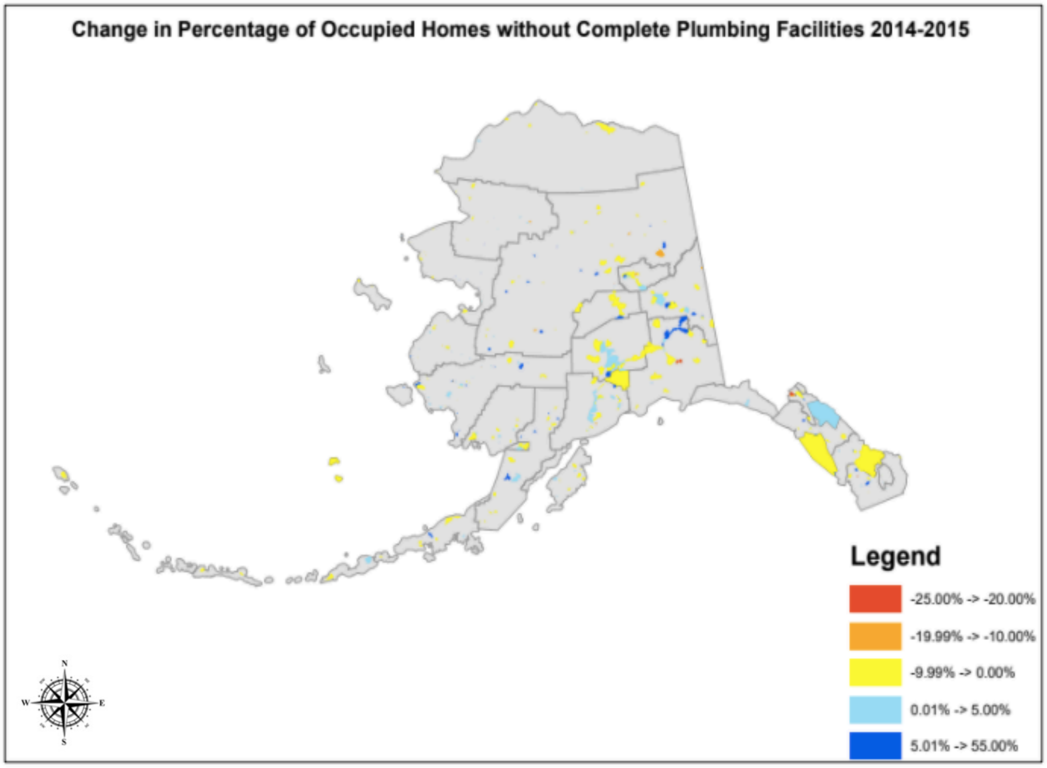

Figure 7: Change in Percentage of Occupied Homes without Complete Plumbing 2014-2015

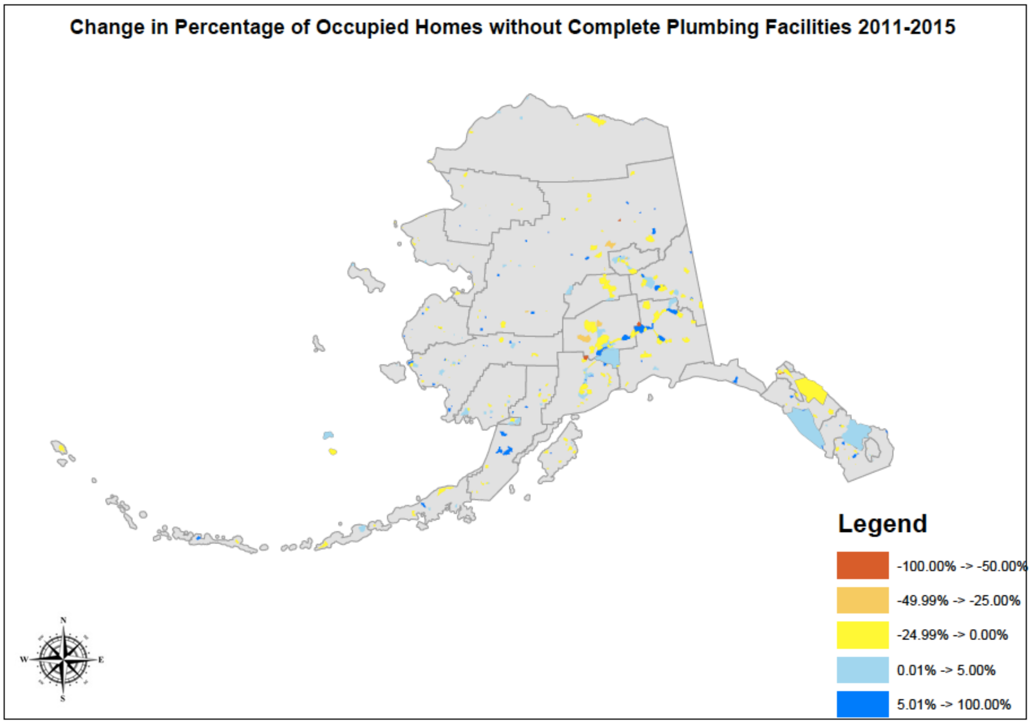

Figure 8: Change in Percentage of Occupied Homes without Complete Plumbing 2011-2015

4.2 Statistical Modeling Results

Table 1 summarizes the parameters influencing the rate of households lacking complete plumbing facilities at in Alaskan places. Unfortunately, the variables regarding poverty status of individuals and educational attainment had a great deal of missing, and as such, could not be used. Variables regarding race, age of structures, and school enrollment were revealed to be statistically insignificant through the modeling process. Notably, in the raw data, the age of structures was provided as a portion of total housing units, not just occupied housing units. For instance, in 2011, the incorporated place of Adak had 54 total households, or occupied housing units. That same year, Adak was reported to have 824 total housing units, occupied and unoccupied. Total housing units was about 15x higher than the occupied housing units.

The margins of error indicated by ACS were quite high. Further, the initial assumptions on which variables to build into the model were based off of previous literature, which did not take temporal decline into account. Temporal decline of water access in Alaska had not been investigated prior to this study, and as such, these variables may be related to the places without water access in that instantaneous moment in time studied in previous research but are insignificant in determining how access changes temporally.

Independent Variable	Estimate	t-Value	p-Value (>|t|)
Percent of Total Households with Income < $30k/year	0.083	3.670	0.000259
Percent of Total Households (Receiving Welfare)	0.037	3.238	0.001256
Percent of Total Population (Male)	0.258	7.265	9.25e-13
Percent of Total Households (w/o Complete Kitchen Facilities)	0.683	23.686	< 2e-16

Table 3: Results from Fixed Effects Model

Table 4 below is the ANOVA table of the fixed effects regression model. While 355 places are studied in this model, ~ 20 places either (1) did not have enough data available or (2) did not change over time. The model does not consider incomplete or time-invariant variables. The complete kitchen facilities variables had the highest variability of the study, and the welfare status of households had the lowest variability, according to Table 4. The complete kitchen facilities variable was the most dispersed in the model, and the welfare status is the least dispersed in the model.

Variable	Sum of Squares	Df	F-Value	Pr (>F)
Percent of Total Households with Income < $30k/year	0.057	1	15.15	~ 0.000
Percent of Total Households Receiving Welfare	0.038	1	10.034	0.001
Percent of Total Population that is Male	0.204	1	53.533	$6.44e^{-13}$
Percent of Total Households w/o Complete Kitchen Facilities	2.329	1	610.817	$< 2.2e^{-16}$
Categorical Variable: Place	17.807	336	13.899	$< 2.2e^{-16}$
Residuals	2.913	764		
Total Sum of Squares	6.150			
Residual Sum of Squares	2.913			
R-Squared	0.526 *			
F-Statistic	212.272			
Overall p-value	$< 2.2e^{-16}$			

Table 4: ANOVA Table

*This R-Squared value is for the within regression model after accounting for fixed effects.

The percentage of total households that earn less than $30,000 per year influences the percentage of homes in a place without complete plumbing facilities. In 2010, the federal poverty level was defined as such: $10,830 for one person, with $3,740 extra for each additional person in a household. For a typical four-person family, the poverty guideline for Alaska was $27,570. This guideline increases slightly to $27,940 in 2011, $28,820 in 2012, $29,440 in 2013, $29,820 in 2014 and to $23,320 in 2015 [46]. This strong connection between plumbing decline and poverty is not surprising. Money is a barrier to repairing plumbing in the household [47]. Lower-income families will forgo paying for expensive repairs in order to pay necessary bills or purchase food. This is also especially likely if there are residents of that place neighbors are accustomed to water-hauling. Indigenous people may also turn to more traditional methods of collecting water, such as rainwater basins and from rivers [2, 4, 6]. However, this barrier cannot be fixed directly through infrastructure improvements, as this failure is at the household level. Governmental intervention might be successful via financial means.

Critical infrastructure may fail outside of the household. For instance, melting permafrost has been the known cause of cracking subterraneous pipelines, a repair that would be funded by governmental entities. Without city water from flowing through existing in-home infrastructure, lower-income households are disincentivized from completing home repairs. At the same time, there is a documented inverted relationship between income and political participation [48], and from previous literature we see that disenfranchised groups tend to have poor water infrastructure. Since water infrastructure is typically maintained by municipal bodies, the most active constituents will be considered when allocating funding and resources. Low political participation increases the risk that a community will not be prioritized by local governments. Furthermore, this correlation will likely only grow larger with time as the feeling of low political efficacy grows. In Wies et al [10], the dilapidated state of their water infrastructure perpetuates the feeling that the government does not care about the community. The size of the apolitical population grows, and the water infrastructure remains broken or nonexistent, and the rate of household plumbing declines.

The modeling process revealed that households receiving welfare are more likely to have incomplete plumbing household facilities. While some welfare is indicative of lower-income, like food stamps [49], the Social Security income and Public Assistance Income are indicative of retired and disabled populations [50]. This makes sense. In fact, aging populations and disabled persons have been found to have lower access to potable water [1, 6, 9, 51]. According to a report on the status of disabled persons in Alaska, they face extreme isolation due to physical barriers and lack of time and energy [52]. Since both home repair and water hauling are both extremely physically demanding [2, 4], the aged and disabled populations must rely on social networks for survival, a unique vulnerability that increases this population's odds of losing plumbing facilities. While the presence of a strong social network may delay an older or disabled individual from losing plumbing access, migration from small Alaskan towns, particularly from Native communities to larger cities in the state like Anchorage and Juneau in hopes of more economic opportunities is very significant [53]. As young families move to the cities, older family members who want to remain close to ancestral lands or disabled individuals who lack the physical ability to move cities, lose their vital social networks, thus exposing them to possible plumbing decline. This presents the cascading effects of water insecurity [6]. Without water infrastructure in the homes of elderly and disabled persons, the risk of possible health problems caused by lack of plumbing is increased for this population. This variable suggests that if governmental bodies aim to provide plumbing access to the people who have incomplete plumbing, households that receive welfare more likely than non-welfare recipients to need the most assistance.

The model also revealed that places with a higher proportion of males are more likely to have a higher percentage of occupied homes without complete plumbing facilities. As predicted, gender and water are strongly interconnected. Some of this correlation can be attributed to the fact that women are more likely to live in poverty than a man. Income was a strong factor in predicting plumbing decline, so these variables are correlated. However, a deeper social issue may also tie into this phenomenon. Of note, women are typically the primary caretakers of the home and of children [54]. As the primary caretakers of the home, women feel responsibility for how their children grow up and the struggles that they face in regards to water and women tended to have more anxiety about water compared to men in communities with irregular water availability due to how it effects their children and families [2, 4]. The literature shows that a lack of plumbing causes higher rates of pediatric lower respiratory infection rates and diarrheal diseases [4, 7]. A mother at the forefront of caring for a sick child will be acutely aware of the negative impacts of inadequate plumbing access. This awareness is confirmed in a study of intrahousehold perceptions of water insecurity in Bolivia where women reported that they conserved water more aggressively during cooking and bathing to save more water for family members [55]. This is not to say that due to necessity, women demand more in-home plumbing. In fact, according to the United Nations, 1 in 3 women lack access to sanitation facilities [56], posing a particular challenge to maintain menstrual hygiene. According to official advice from the United Nations, safe menstrual hygiene requires access to flush toilets, as well as clean water and soap for washing of the hands and body throughout the menstrual cycle [57]. This particular challenge that females face may explain some of the significance of this parameters. While female demands for water do not directly explain why places with higher percentages of males tend to have less complete plumbing, it does correlate to the other variables deemed important. Lower-income earners may not prioritize plumbing repairs over other expenses. However, if the primary caretaker of the home, most likely a female, sees value in maintaining plumbing for caretaking or menstrual hygiene, this expense may become a priority, as compared to male households. Similarly, this value regarding household plumbing may tend to increase political participation of women to make water infrastructure failures a priority of their representatives in government.

The last variable that the model found to be significant is the percentage of homes without complete kitchen facilities. Complete kitchen facilities are defined as having three of the following operational features— a (1) sink with a faucet, (2) a stove or range, and (3) a refrigerator [26]. Complete plumbing facilities, as defined by ACS [26], require (1) hot and cold running water, (2) a flush toilet and (3) a bathtub or shower all located inside of the house. The two variables, complete kitchen facilities and complete plumbing facilities, overlap with the presence of a sink. These two variables are binary: either all three conditions are met, or the facilities are considered absent or incomplete. So, while a household could have complete plumbing facilities and incomplete kitchen facilities, or vice versa, these variables are related. Further, operational kitchens are costly and may not be in the budget of a family below the Alaskan poverty guideline. Similar to the expense of plumbing repair, kitchen maintenance may not be prioritized by a household under tight financial conditions, especially if this household is indigenous. Indigenous communities have methods of cooking and storing food in traditional ways that do not require a kitchen [2]. This variable is at the intersection of income, race, and plumbing.

These four variables begin to develop possible action plans to target populations that are likely experiencing temporally decreasing proportions of households with incomplete plumping. Income levels may suggest the need for an increased minimum wage or more robust government assistance program for lower-income families. This could also prompt increased voter registration efforts in lower-income regions or more town halls in regions with historically low political participation to get a better understanding of which places are in decline and need government intervention. For retired and disabled persons, a program could be created where these individuals without strong networks could be regularly contacted and provided home repair service, if need be. Finally, while the gender variable is difficult to translate into policy, this variable does begin to show lawmakers where complete household plumbing decline may occur and to ensure that the infrastructure in that region is not vulnerable.

CHAPTER 5: CONCLUSION

Alaska is historically the state with the lowest percentage of occupied homes without in-home plumbing [1], and while this percentage has improved overall on the aggregate since the 1960s when this topic was initially identified through the use of the United States census, some places in Alaska are still experiencing decline in water access since 2011. Previous studies have reaffirmed the importance of water access by discussing the impacts on daily life like physical labor of water hauling that costs days at a time or the burden placed on women and caretakers of the household. Public health experts have weighed in by discussing lack of water access tied to increased consumption of unhealthy drinks and respiratory infections of children. While the implications of a lack of water access in Alaska were well-documented, studies about the temporal changes are absent from the conversation. Studies done on water infrastructure in Alaska were time-invariant and reliant on the assumption that water access only improves in the United States.

This research shows that where this decline in water access and who is losing water access is not random, as measured by those household with incomplete plumbing. Alaskan places with a higher percentage of: low-income residents, those on welfare, men as compared to women, and total households without complete kitchen facilities, are likely to have a higher percentage of total households without complete plumbing facilities. By specifically identifying social forces that influence plumbing, water resource planners and municipal bodies are better equipped to reverse this decline or anticipate areas of high risk to declining plumbing. As this decline happens in small places to select populations of people, policy must too be localized to be effective.

This study shows potential for future research. Researchers could look at decline on a more granular basis instead of from five-year data through to present day. The large changes in percentages in complete plumbing data imply that that are several forces at work that causes a home or the town to have plumbing one year and not the next year. Future research could look at which specific types of welfare are the most statistically significant in predicting loss of plumbing.

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APPENDIX

Appendix 1: Fixed Effects of Census-Designated & Incorporated Places

	ESTIMATE	STD. ERROR	T-VALUE	PR(>|T|)
ADAK	-0.135	0.035	-3.812	0.000
AKHIOK	-0.171	0.040	-4.254	0.000
AKIACHAK	0.002	0.041	0.053	0.958
AKIAK	-0.302	0.038	-7.998	0.000
AKUTAN	-0.252	0.042	-6.018	0.000
ALAKANUK	-0.113	0.039	-2.852	0.004
ALATNA	0.200	0.045	4.475	0.000
ALCAN BORDER	-0.158	0.041	-3.828	0.000
ALEKNAGIK	-0.172	0.038	-4.548	0.000
ALENEVA	-0.122	0.035	-3.474	0.001
ALLAKAKET	0.041	0.046	0.889	0.374
AMBLER	-0.064	0.039	-1.631	0.103
ANAKTUVUK PASS	-0.169	0.037	-4.541	0.000
ANCHOR POINT	-0.106	0.037	-2.851	0.004
ANCHORAGE	-0.159	0.036	-4.350	0.000
ANDERSON	-0.185	0.040	-4.629	0.000
ANGOON	-0.154	0.040	-3.818	0.000
ANIAK	-0.118	0.037	-3.207	0.001
ANVIK	-0.202	0.039	-5.215	0.000
ARCTIC VILLAGE	0.138	0.045	3.104	0.002
ATKA	-0.198	0.040	-5.005	0.000
ATMAUTLUAK	0.371	0.041	9.016	0.000
ATQASUK	-0.048	0.038	-1.275	0.203
BADGER	-0.150	0.037	-4.111	0.000
BARROW	-0.139	0.037	-3.739	0.000
BEAR CREEK	-0.139	0.037	-3.782	0.000
BEAVER	-0.057	0.038	-1.490	0.137
BELUGA	0.016	0.037	0.427	0.669
BETHEL	-0.148	0.036	-4.082	0.000
BETTLES	-0.095	0.041	-2.326	0.020
BIG DELTA	-0.162	0.038	-4.234	0.000
BIG LAKE	-0.145	0.037	-3.934	0.000
BIRCH CREEK	0.129	0.051	2.529	0.012

BREVIG MISSION	-0.258	0.039	-6.610	0.000
BUCKLAND	0.161	0.038	4.196	0.000
BUFFALO SOAPSTONE	-0.110	0.036	-3.060	0.002
BUTTE	-0.150	0.037	-4.090	0.000
CANTWELL	-0.066	0.038	-1.743	0.082
CENTRAL	0.098	0.039	2.504	0.012
CHALKYITSIK	0.125	0.044	2.827	0.005
CHASE	-0.014	0.051	-0.266	0.790
CHEFORNAK	0.238	0.043	5.593	0.000
CHENA RIDGE	-0.117	0.037	-3.181	0.002
CHENEGA	-0.179	0.037	-4.882	0.000
CHEVAK	-0.233	0.039	-5.952	0.000
CHICKALOON	-0.169	0.037	-4.562	0.000
CHIGNIK	-0.102	0.036	-2.816	0.005
CHIGNIK LAGOON	-0.131	0.034	-3.787	0.000
CHIGNIK LAKE	-0.142	0.036	-3.918	0.000
CHINIAK	-0.223	0.040	-5.524	0.000
CHISTOCHINA	-0.074	0.037	-2.025	0.043
CHITINA	0.041	0.036	1.143	0.253
CHUATHBALUK	-0.064	0.037	-1.735	0.083
CIRCLE	0.026	0.044	0.584	0.559
CLAM GULCH	0.006	0.040	0.161	0.872
CLARK'S POINT	-0.146	0.036	-3.998	0.000
COFFMAN COVE	-0.247	0.041	-5.978	0.000
COHOE	-0.121	0.037	-3.241	0.001
COLD BAY	-0.046	0.038	-1.230	0.219
COLLEGE	-0.158	0.037	-4.286	0.000
COOPER LANDING	-0.115	0.036	-3.193	0.001
COPPER CENTER	-0.153	0.037	-4.070	0.000
CORDOVA	-0.176	0.038	-4.639	0.000
COVENANT LIFE	-0.079	0.039	-2.000	0.046
CRAIG	-0.170	0.037	-4.580	0.000
CROOKED CREEK	0.271	0.040	6.804	0.000
CROWN POINT	-0.058	0.035	-1.645	0.100
DEERING	-0.037	0.038	-0.982	0.327
DELTA JUNCTION	-0.142	0.038	-3.782	0.000
DELTANA	-0.149	0.037	-4.005	0.000

DIAMOND RIDGE	-0.140	0.037	-3.801	0.000
DILLINGHAM	-0.134	0.036	-3.690	0.000
DIOMEDE	0.115	0.042	2.735	0.006
DOT LAKE	0.190	0.070	2.737	0.006
DOT LAKE VILLAGE	-0.225	0.040	-5.685	0.000
DRY CREEK	-0.003	0.041	-0.078	0.938
EAGLE	0.065	0.040	1.615	0.107
EAGLE VILLAGE	-0.148	0.042	-3.514	0.000
EDNA BAY	-0.887	0.052	-17.173	0.000
EEK	0.327	0.042	7.831	0.000
EGEGIK	-0.183	0.040	-4.608	0.000
EIELSON AFB	-0.154	0.036	-4.282	0.000
EKWOK	-0.073	0.039	-1.885	0.060
ELFIN COVE	-0.128	0.034	-3.770	0.000
ELIM	-0.192	0.040	-4.808	0.000
EMMONAK	-0.106	0.038	-2.767	0.006
ESTER	-0.057	0.036	-1.571	0.117
EVANSVILLE	-0.116	0.035	-3.352	0.001
FAIRBANKS	-0.175	0.037	-4.719	0.000
FALSE PASS	-0.191	0.038	-5.022	0.000
FARM LOOP	-0.123	0.036	-3.376	0.001
FARMERS LOOP	-0.140	0.037	-3.743	0.000
FERRY	-0.102	0.060	-1.701	0.089
FISHHOOK	-0.158	0.037	-4.308	0.000
FORT GREELY	-0.151	0.037	-4.121	0.000
FORT YUKON	-0.057	0.039	-1.475	0.141
FOUR MILE ROAD	-0.094	0.043	-2.171	0.030
FOX	-0.154	0.038	-4.110	0.000
FOX RIVER	-0.175	0.036	-4.817	0.000
FRITZ CREEK	-0.080	0.037	-2.198	0.028
FUNNY RIVER	-0.166	0.039	-4.252	0.000
GAKONA	-0.122	0.037	-3.333	0.001
GALENA	-0.093	0.037	-2.523	0.012
GAMBELL	-0.081	0.040	-2.033	0.042
GAME CREEK	-0.142	0.037	-3.903	0.000
GATEWAY	-0.155	0.036	-4.269	0.000
GLACIER VIEW	-0.043	0.039	-1.104	0.270

GLENNALLEN	-0.095	0.038	-2.467	0.014
GOLDSTREAM	0.038	0.037	1.015	0.311
GOLOVIN	-0.033	0.037	-0.899	0.369
GOODNEWS BAY	-0.179	0.042	-4.284	0.000
GRAYLING	0.023	0.041	0.555	0.579
GULKANA	0.047	0.038	1.246	0.213
GUSTAVUS	-0.067	0.037	-1.812	0.070
HAINES	-0.167	0.042	-3.961	0.000
HALIBUT COVE	0.287	0.051	5.633	0.000
HAPPY VALLEY	-0.123	0.042	-2.905	0.004
HARDING-BIRCH LAKES	-0.257	0.042	-6.131	0.000
HEALY	-0.146	0.040	-3.652	0.000
HOLLIS	-0.076	0.043	-1.783	0.075
HOLY CROSS	-0.004	0.043	-0.103	0.918
HOMER	-0.167	0.041	-4.077	0.000
HOONAH	-0.160	0.041	-3.860	0.000
HOOPER BAY	0.202	0.046	4.397	0.000
HOPE	-0.035	0.046	-0.759	0.448
HOUSTON	-0.138	0.041	-3.344	0.001
HUGHES	0.106	0.040	2.624	0.009
HUSLIA	-0.113	0.042	-2.674	0.008
HYDABURG	-0.201	0.042	-4.758	0.000
HYDER	0.151	0.042	3.567	0.000
IGIUGIG	-0.036	0.040	-0.901	0.368
ILIAMNA	-0.154	0.040	-3.842	0.000
JUNEAU	-0.166	0.041	-4.060	0.000
KACHEMAK	-0.125	0.040	-3.145	0.002
KAKE	-0.142	0.043	-3.318	0.001
KAKTOVIK	-0.166	0.042	-3.928	0.000
KALIFORNSKY	-0.134	0.040	-3.325	0.001
KALTAG	-0.126	0.045	-2.781	0.006
KARLUK	-0.130	0.040	-3.245	0.001
KASAAN	-0.206	0.041	-5.025	0.000
KASIGLUK	0.095	0.047	2.024	0.043
KASILOF	-0.130	0.040	-3.263	0.001
KENAI	-0.169	0.041	-4.124	0.000
KENNY LAKE	-0.163	0.042	-3.918	0.000

KETCHIKAN	-0.181	0.041	-4.378	0.000
KIANA	-0.084	0.042	-1.981	0.048
KING COVE	-0.218	0.044	-4.964	0.000
KING SALMON	-0.173	0.043	-4.066	0.000
KIPNUK	0.211	0.046	4.616	0.000
KIVALINA	0.220	0.047	4.691	0.000
KLAWOCK	-0.187	0.043	-4.389	0.000
KLUKWAN	-0.209	0.043	-4.906	0.000
KNIK RIVER	-0.091	0.041	-2.235	0.026
KNIK-FAIRVIEW	-0.146	0.041	-3.589	0.000
KOBUK	-0.211	0.041	-5.172	0.000
KODIAK	-0.168	0.041	-4.080	0.000
KODIAK STATION	-0.163	0.041	-3.960	0.000
KOKHANOK	-0.147	0.041	-3.618	0.000
KOLIGANEK	-0.015	0.040	-0.380	0.704
KONGIGANAK	0.266	0.046	5.764	0.000
KOTLIK	-0.121	0.043	-2.793	0.005
KOTZEBUE	-0.135	0.041	-3.308	0.001
KOYUK	-0.171	0.046	-3.745	0.000
KOYUKUK	0.143	0.045	3.163	0.002
KUPREANOF	0.097	0.040	2.456	0.014
KWETHLUK	0.264	0.044	5.937	0.000
KWIGILLINGOK	0.077	0.043	1.806	0.071
LAKE LOUISE	-0.121	0.066	-1.852	0.064
LAKE MINCHUMINA	0.329	0.050	6.603	0.000
LAKES	-0.166	0.041	-4.062	0.000
LARSEN BAY	-0.118	0.042	-2.797	0.005
LAZY MOUNTAIN	-0.125	0.040	-3.117	0.002
LEVELOCK	0.123	0.042	2.957	0.003
LIME VILLAGE	0.117	0.048	2.458	0.014
LIVENGOOD	0.011	0.050	0.227	0.820
LOWELL POINT	-0.171	0.066	-2.596	0.010
LOWER KALSKAG	0.108	0.042	2.554	0.011
LUTAK	-0.031	0.036	-0.854	0.393
MANLEY HOT SPRINGS	0.005	0.043	0.118	0.906
MANOKOTAK	-0.034	0.044	-0.776	0.438
MARSHALL	-0.071	0.043	-1.666	0.096

MCCARTHY	-0.170	0.042	-4.035	0.000
MCGRATH	-0.129	0.041	-3.169	0.002
MCKINLEY PARK	-0.129	0.039	-3.341	0.001
MEADOW LAKES	-0.161	0.041	-3.904	0.000
MEKORYUK	0.012	0.044	0.268	0.789
MENDELTNA	0.134	0.042	3.161	0.002
MENTASTA LAKE	-0.106	0.043	-2.447	0.015
METLAKATLA	-0.189	0.042	-4.447	0.000
MINTO	-0.100	0.044	-2.258	0.024
MOOSE CREEK	-0.173	0.042	-4.104	0.000
MOOSE PASS	-0.186	0.043	-4.332	0.000
MOSQUITO LAKE	-0.224	0.045	-4.926	0.000
MOUNTAIN VILLAGE	-0.041	0.043	-0.938	0.348
MUD BAY	0.178	0.044	4.059	0.000
NAKNEK	-0.159	0.040	-3.976	0.000
NANWALEK	-0.199	0.042	-4.757	0.000
NAPAKIAK	0.165	0.045	3.665	0.000
NAPASKIAK	-0.046	0.043	-1.071	0.285
NAUKATI BAY	-0.292	0.049	-5.996	0.000
NELCHINA	-0.148	0.040	-3.703	0.000
NELSON LAGOON	-0.144	0.039	-3.684	0.000
NENANA	-0.124	0.042	-2.947	0.003
NEW ALLAKAKET	0.074	0.050	1.480	0.139
NEW STUYAHOK	-0.036	0.044	-0.816	0.415
NEWHALEN	-0.122	0.040	-3.078	0.002
NEWTOK	0.158	0.047	3.338	0.001
NIGHTMUTE	0.394	0.044	9.036	0.000
NIKISKI	-0.173	0.041	-4.187	0.000
NIKOLAEVSK	0.001	0.042	0.032	0.974
NIKOLAI	-0.007	0.046	-0.160	0.873
NIKOLSKI	-0.258	0.045	-5.674	0.000
NINILCHIK	-0.159	0.042	-3.804	0.000
NOATAK	-0.156	0.044	-3.568	0.000
NOME	-0.154	0.041	-3.776	0.000
NONDALTON	0.049	0.042	1.181	0.238
NOORVIK	-0.133	0.043	-3.103	0.002
NORTH POLE	-0.165	0.040	-4.074	0.000

NORTHWAY	-0.067	0.040	-1.660	0.097
NORTHWAY JUNCTION	-0.083	0.041	-2.008	0.045
NORTHWAY VILLAGE	0.096	0.048	2.013	0.044
NUIQSUT	-0.127	0.041	-3.138	0.002
NULATO	-0.123	0.044	-2.794	0.005
NUNAM IQUA	-0.070	0.043	-1.631	0.103
NUNAPITCHUK	-0.108	0.043	-2.521	0.012
OLD HARBOR	-0.166	0.042	-3.943	0.000
OSCARVILLE	0.235	0.052	4.481	0.000
OUZINKIE	-0.178	0.042	-4.218	0.000
PALMER	-0.178	0.041	-4.331	0.000
PAXSON	-0.138	0.040	-3.444	0.001
PEDRO BAY	-0.041	0.040	-1.038	0.300
PELICAN	-0.090	0.040	-2.231	0.026
PERRYVILLE	0.183	0.042	4.310	0.000
PETERSBURG	-0.184	0.041	-4.484	0.000
PILOT POINT	-0.145	0.042	-3.451	0.001
PILOT STATION	-0.100	0.043	-2.296	0.022
PITKAS POINT	0.275	0.043	6.407	0.000
PLATINUM	-0.005	0.047	-0.099	0.921
PLEASANT VALLEY	-0.169	0.042	-4.058	0.000
POINT BAKER	0.250	0.050	5.028	0.000
POINT HOPE	-0.069	0.041	-1.673	0.095
POINT LAY	0.032	0.041	0.762	0.447
POINT MACKENZIE	-0.088	0.047	-1.874	0.061
POINT POSSESSION	-0.254	0.056	-4.516	0.000
POPE-VANNOY LANDING	-0.033	0.062	-0.535	0.593
PORT ALEXANDER	0.069	0.042	1.638	0.102
PORT ALSWORTH	-0.095	0.039	-2.451	0.014
PORT GRAHAM	-0.175	0.044	-4.024	0.000
PORT HEIDEN	-0.185	0.042	-4.448	0.000
PORT LIONS	-0.175	0.041	-4.267	0.000
PORT PROTECTION	-0.660	0.047	-13.905	0.000
PRIMROSE	-0.173	0.042	-4.125	0.000
QUINHAGAK	-0.094	0.046	-2.052	0.040
RAMPART	0.431	0.042	10.145	0.000
RED DEVIL	-0.074	0.042	-1.760	0.079

RIDGEWAY	-0.177	0.042	-4.247	0.000
RUBY	0.036	0.043	0.839	0.402
RUSSIAN MISSION	-0.031	0.043	-0.722	0.471
SALAMATOF	-0.191	0.043	-4.427	0.000
SALCHA	-0.121	0.041	-2.939	0.003
SAND POINT	-0.195	0.044	-4.417	0.000
SAVOONGA	-0.306	0.045	-6.773	0.000
SAXMAN	-0.207	0.044	-4.742	0.000
SCAMMON BAY	0.182	0.044	4.129	0.000
SELAWIK	-0.054	0.043	-1.252	0.211
SELDOVIA	-0.188	0.042	-4.532	0.000
SELDOVIA VILLAGE	-0.140	0.042	-3.325	0.001
SEWARD	-0.211	0.043	-4.908	0.000
SHAGELUK	0.220	0.046	4.820	0.000
SHAKTOOLIK	-0.179	0.043	-4.166	0.000
SHISHMAREF	0.253	0.045	5.680	0.000
SHUNGNAK	-0.077	0.042	-1.828	0.068
SILVER SPRINGS	-0.151	0.042	-3.644	0.000
SITKA	-0.155	0.041	-3.827	0.000
SKAGWAY	-0.159	0.041	-3.922	0.000
SKWENTNA	0.489	0.054	8.992	0.000
SLANA	-0.148	0.043	-3.426	0.001
SLEETMUTE	-0.007	0.045	-0.154	0.878
SOLDOTNA	-0.174	0.041	-4.253	0.000
SOUTH NAKNEK	-0.067	0.040	-1.663	0.097
SOUTH VAN HORN	-0.172	0.041	-4.188	0.000
ST. GEORGE	-0.210	0.041	-5.172	0.000
ST. MARY'S	-0.123	0.041	-2.975	0.003
ST. MICHAEL	-0.107	0.041	-2.590	0.010
ST. PAUL	-0.188	0.043	-4.433	0.000
STEBBINS	0.217	0.045	4.765	0.000
STEELE CREEK	-0.125	0.040	-3.092	0.002
STERLING	-0.164	0.041	-4.007	0.000
STEVENS VILLAGE	0.048	0.051	0.944	0.345
STONY RIVER	0.052	0.046	1.132	0.258
SUNRISE	0.587	0.052	11.247	0.000
SUSITNA	-0.077	0.045	-1.726	0.085

SUSITNA NORTH	-0.065	0.041	-1.564	0.118
SUTTON-ALPINE	-0.213	0.045	-4.714	0.000
TAKOTNA	-0.024	0.040	-0.611	0.542
TALKEETNA	-0.098	0.041	-2.370	0.018
TANACROSS	-0.075	0.044	-1.731	0.084
TANAINA	-0.171	0.041	-4.189	0.000
TANANA	0.017	0.044	0.384	0.701
TATITLEK	-0.159	0.040	-3.988	0.000
TAZLINA	-0.161	0.043	-3.750	0.000
TELLER	0.205	0.044	4.646	0.000
TENAKEE SPRINGS	0.120	0.042	2.885	0.004
TETLIN	0.227	0.044	5.187	0.000
THORNE BAY	-0.138	0.042	-3.279	0.001
TOGIAK	-0.050	0.043	-1.146	0.252
TOK	-0.141	0.041	-3.447	0.001
TOKSOOK BAY	0.115	0.044	2.655	0.008
TONSINA	-0.112	0.039	-2.881	0.004
TRAPPER CREEK	-0.124	0.041	-2.993	0.003
TULUKSAK	0.167	0.047	3.559	0.000
TUNTUTULIAK	0.236	0.047	4.982	0.000
TUNUNAK	0.105	0.045	2.321	0.021
TWIN HILLS	-0.156	0.043	-3.615	0.000
TWO RIVERS	-0.029	0.043	-0.668	0.504
TYONEK	-0.191	0.041	-4.614	0.000
UGASHIK	0.010	0.042	0.234	0.815
UNALAKLEET	-0.160	0.042	-3.765	0.000
UNALASKA	-0.168	0.042	-3.967	0.000
UPPER KALSKAG	-0.005	0.042	-0.127	0.899
VALDEZ	-0.152	0.040	-3.758	0.000
VENETIE	0.096	0.048	2.001	0.046
WAINWRIGHT	-0.073	0.042	-1.752	0.080
WALES	0.388	0.044	8.772	0.000
WASILLA	-0.179	0.041	-4.344	0.000
WHALE PASS	-0.076	0.044	-1.716	0.087
WHITE MOUNTAIN	-0.113	0.044	-2.534	0.011
WHITESTONE	-0.110	0.046	-2.374	0.018
WHITESTONE LOGGING CAMP	-0.150	0.044	-3.426	0.001

WHITTIER	-0.233	0.041	-5.690	0.000
WILLOW CREEK	0.028	0.052	0.535	0.593
WILLOW	-0.074	0.041	-1.784	0.075
WISEMAN	0.214	0.069	3.127	0.002
WOMENS BAY	-0.125	0.040	-3.151	0.002
WRANGELL	-0.161	0.041	-3.928	0.000
YAKUTAT	-0.144	0.041	-3.513	0.000